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Trade-Off between Animal Welfare and Environmental Impacts of Beef Production: An Analysis of Presentation Effects on Consumer Choice

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Despite many consumers' intuitions to the contrary, improvements in farm animal welfare can conflict with environmental objectives, particularly regarding greater intensification of production systems. Using a discrete choice experiment, this study determines how consumers make trade-offs between increased animal welfare and lower levels of environmental impact. We assess the sensitivity of results by varying how attributes were presented and what information was available to respondents. Overall, results suggest consumers are willing to trade environment for animal welfare, but the extent of this trade-off strongly depends on how the information is conveyed to consumers.

Key words: animal welfare, discrete choice, presentation effects, beef

Introduction

Global population is projected to reach 9 billion by the year 2048 (U.S. Census Bureau, 2004). Increased global affluence will result in an increase in global protein requirements per capita (Keyzer et al., 2005). With more people wanting to consume meat, production of animal protein will need to increase by 70% from 2005 to 2050 (Food and Agriculture Organization of the United Nations, 2009). Increased global demand for animal protein has the potential to exacerbate environmental problems associated with climate change and biodiversity loss (Gerber et al., 2013). Meat-containing diets worldwide have been estimated to require 6 times more land than wheat-based diets (Gerbens-Leenes and Nonhebel, 2002), calling into question the ability of animal agriculture to efficiently meet growing caloric needs. One potential way to meet protein demand while mitigating environmental damages is to intensify animal agriculture, which can reduce the environmental impact per unit of food produced (Fiala, 2008). However, intensification practices (e.g., battery cages, gestation crates, feedlots) are often argued to decrease farm animal well-being (Knowles et al., 2008; Gonyou, 2005; Loneragan et al., 2001).

Public concern regarding the effects of meat production on both animal welfare and environmental quality are prompting policy changes and industry shifts (Alonso, González-Montaña, and Lomillos, 2020; Sanchez-Sabate and Sabaté, 2019). Recent examples include Proposition 12 in California, which will outlaw sales of eggs and pork from battery cages and gestation crates in that state, and the emergence of plant-based and lab-grown meat substitutes (Van Loo, Caputo, and Lusk, 2020). Commonly, animal welfare and environmental stewardship are considered separately or are believed (often incorrectly) to be congruent (Harper and Makatouni, 2002; Alonso, González-Montaña, and Lomillos, 2020). Recent studies, however, have demonstrated a nexus between these two issues, illustrating a trade-off in which improvements for

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animal welfare often result in greater environmental impact from meat production and vice versa (Place and Mitloehner, 2014; Shields and Orme-Evans, 2015; Place, 2018). Understanding consumer knowledge and attitudes toward this trade-off could be useful to policy makers and industry leaders. For instance, recent pledges by Walmart, McDonald's, and Kroger to move toward cage-free eggs could have major implications for the egg-producing industry (Lusk, 2018a).

The primary objective of this study is to determine consumer preferences for attributes of ground beef products, specifically when presented a trade-off between reductions in environmental impact and improvements in animal welfare. Because consumers are largely unknowledgeable of meat production practices (Verbeke and Viaene, 2000; Lusk, 2018b), it might be expected that consumer choices would be significantly influenced by the way information and choices are presented. As a result, this study also incorporates multiple survey designs and information treatments to determine the effect of presentation on consumer choice.

A large literature has studied consumer willingness to pay (WTP) for health, safety, environment, taste, and animal welfare-related attributes in meat (e.g., see reviews in Schroeder and Tonsor, 2011; Yang and Renwick, 2019; Cicia, Cicia, and Colantuoni, 2010, or specific studies such as Belcher, Germann, and Schmutz, 2007; Dickinson and Bailey, 2002; Loureiro and Umberger, 2004; Li et al., 2016; Tonsor and Shupp, 2009). However, most studies either focus on environmental issues or animal welfare issues; the extant literature does not provide a clear assessment of the trade-offs consumers are willing to make between environment and animal welfare attributes, particularly when sensitivity to information and framing effects is considered. This study aims to fill this gap in the literature.

Background

Environmental Inputs in Animal Agriculture

Capper (2011) compared environmental inputs for beef production systems in the United States in 1977 and in 2007, finding that increases in efficiency in modern beef production systems resulted in considerably fewer resources being used per pound of beef than in 1977. Production of an equivalent amount of beef in 2007 required 69.9% fewer animals, 81.4% less feedstuffs, 87.9% less water and 67.0% less land relative to a comparable system in 1977. This efficiency also resulted in a 16.3% reduction in carbon emissions, demonstrating a positive relationship between agricultural intensification and reduced environmental impact. Capper, Cady, and Bauman (2009) demonstrated a similarly reduced environmental impact in dairy production from 1944 to 2007.

The relationship between agricultural production and intensification has been studied across other animal production systems as well. Havenstein, Ferket, and Qureshi (2003) compared broiler chicken production systems from 1957 and 2001 and showed similar increases of efficiency at the same time the industry consolidated and intensified. The study showed that the 1957 broilers required 101 days and an average of 8,022 g of feed to reach a body weight of 1,815 g. Broilers in 2001 reached the same body weight after just 32 days and 2,668 g of feed. These findings were corroborated in a study of the Canadian poultry industry by Vergé et al. (2009), who found that greenhouse gas emissions per kilogram of live weight for broiler chickens had decreased by 19% from 1981 to 2006.

In the swine industry, large indoor confinement systems have been shown to result in decreased nutrient leaching, soil compaction, and nutrient loading in soils compared to outdoor housing systems (Quintern and Sundrum, 2006). These findings suggest that a potential solution to meet the growing global demand for food protein while reducing environmental harm could be further intensification of animal agriculture. However, the benefits derived by animal agriculture intensification could have adverse effects on the animals themselves.

Farm Animal Welfare

A main driver of increased production efficiency is genetic selection of animals that demonstrate higher growth rates, milk production, and feed efficiency (Place, 2018). However, these genetic "improvements" may have a negative impact on the animals' overall well-being. Efficiency increases in broiler chicken production from genetic selection have been linked to lameness and difficulty walking (Knowles et al., 2008) and higher tendency toward cardiovascular problems (Julian, 1999). Concern for animal welfare extends to breeder birds as well, with studies showing higher male aggression levels toward females (Millman, Duncan, and Widowski, 2000), decreased fertility, (McGary et al., 2002), and other reproductive issues (Robinson, Robinson, and Scott, 1991; Bilcik and Estevez, 2005) resulting from genetic selection.

The use of gestation crates and group stalls in swine production generates welfare concerns, including decreased mobility, confinement injuries, and denial of benefits arising from exercise (Gonyou, 2005). It should be noted that the benefits to welfare of these practices (e.g., regulated individual feeding and protection from aggression) may mitigate the negative concerns (Croney and Millman, 2007), although the evidence is inconclusive.

In the cattle industry, the use of feedlots to quickly add weight to an animal before slaughter has potential negative animal welfare implications. Loerch and Fluharty (1999) showed that during transportation from farm to feedlot, some beef cattle experience feed and water deprivation, overcrowding, and low-quality sanitation. Once put in the feedlot, animals may be subjected to new pathogens and low air quality, which can cause bovine respiratory disease (BRD) and increased mortality rates (Loneragan et al., 2001). BRD has been reported to affect 14.4% of cattle in feedlots (Edwards, 2010). Loss from BRD also increased from 10.3 deaths per thousand in 1994 to 14.2 deaths per thousand in 1999 (Loneragan et al., 2001).

Presentation Effect on Willingness to Pay

Stated preference experiments are often designed to measure preferences for new or unfamiliar items for which respondents may not have well-formed preferences. Moreover, the decision tasks present various levels of cognitive difficulty. These combined factors suggest that design dimensions—including the number of choice options per question, the number of attributes which define each alternative, the amount of levels possible for each attribute, the range between each attribute level and the number of choice option questions each participant must answer— can have significant impacts on choice and WTP (Caussade et al., 2005; Hensher, Rose, and Greene, 2005; Hensher, 2006; Dellaert, Donkers, and van Soest, 2012).

Another crucial aspect of choice experiment (CE) design is the way in which each of the trade-offs are presented to the respondent. Jansen et al. (2009) found significant differences in respondent preferences for attributes of housing structures when presented as text only, text and color photo, and text and black-and-white impression. They suggested that respondents are more likely to develop their preferences from images than from text. Orzechowski et al. (2005) compared the use of verbal descriptions and multimedia (virtual reality) presentations on housing preferences. The verbal-description-only presentation style produced better face validity of the price attribute, where the estimated models were more successful at predicting participants' holdout choices made prior to the CE. However, the multimedia approach implied fewer random and inconsistent responses. Bateman et al. (2009) suggested that improving the ease of evaluation of CE information can affect preferences in land use studies. Comparing numeric, numeric and virtual reality (VR), and VR-only presentation styles, VR produced the lowest level of response variability and a significant reduction in the asymmetry between willingness-to-pay and willingness-to-accept (Bateman et al., 2009). Using VR might also reduce hypothetical bias to a greater extent than text representations in choice experiments (Fang et al., 2021).

Another consideration when constructing attribute levels is the range of values (for numeric attributes) and the size of graphics (for visual attributes). Chandon and Wansink (2007) use a "psychophysical" model to observe how subjects' ability to accurately assess increases in meal size and calorie count diminishes as variables and image representations grow larger. This effect is important to note when surveys use large numeric values and visual representations of attributes.

Methods

Choice Experiment and Survey Design

This study uses a CE to determine consumer preference, as is common practice in meat demand analysis (Lusk, Roosen, and Fox, 2003; Mennecke et al., 2007; Lusk, 2018b). CE methods have been shown to create marginal WTP estimates that are not statistically different from real purchases and that produce market share estimates similar to scanner data (Lusk and Schroeder, 2004; Chang, Lusk, and Norwood, 2009). Louviere, Hensher, and Swait (2000) offer a thorough overview of CE methods.

We developed three CE surveys to analyze consumer preferences for beef when presented with a trade-off between improvements in farm animal welfare and reductions in environmental cost. Respondents made repeated choices between options for a pound of ground beef with varying levels of attributes, including price. To present the intended trade-off, we created a list of seven attributes, including three relating to animal welfare, three relating to environmental costs, and price. Levels for price ranged from \$1.99 to \$5.99 in \$0.50 increments.

We selected grassfed, free of added growth hormones (AGH), and mortality rate as the three attributes to represent animal welfare. While mortality rate can be directly perceived as related to animal welfare, there is some concern that grassfed and AGH free could be conflated with benefits of food safety (Yang, Raper, and Lusk, 2017) or sustainability (Stampa, Schipmann-Schwarze, and Hamm, 2020). However, multiple studies have shown that terms such as "grassfed" and "pasture raised" are more often associated with higher animal well-being than with human health or environmental concerns (Pirog, 2004; Conner and Oppenheim, 2008; Schuppli, von Keyserlingk, and Weary, 2014; Kühl, Gauly, and Spiller, 2019). Qualitative reviews have also shown that "added growth hormone free" is similarly most associated with concerns for cattle quality of life (Cardoso et al., 2015; Ventura et al., 2016; Cardoso, von Keyserlingk, and Hötzel, 2019).

Each question presented two options for a pound of ground beef with varying attribute levels and a third option to purchase neither. We used a number of sources to generate realistic levels for environmental impacts of beef production (Beckett and Oltjen, 1993; de Vries and de Boer, 2010; Capper, 2010; Herrero et al., 2013; Capper, 2011). The amounts were adjusted slightly so that the use of color and sizing ensured ranges of one attribute did not dominate that of others. For example, Capper (2010) found that grassfed systems use roughly 4 times more water than conventional beef but only 1.4 times as much fossil fuel. To compensate for this disparity, the high levels of all the environmental inputs were approximately 1.5 times as high as the low levels. Table 1 shows each attribute level for each of the three presentation styles.

With six attributes varying at two levels and price varying over nine, there are $2^6 \times 9 = 576$ ground beef options that could be presented. To reduce the number of possibilities to a more reasonable level while still extracting as much information as possible, we selected 12 options using D-efficiency criteria in software Ngene, which minimizes the standard errors of a multinomial logit model. Each version/treatment used the same experimental design, such that each choice option conveyed the same magnitude of environmental and welfare trade-off across surveys. Figures 1–3 show the same choice option presented uniquely by each design.

Table 1. Attribute Representations and Levels in Three Presentation Designs

Attribute	Text	Visual	Label
Land use	320 sq ft, 220 sq ft	320 sq ft, 220 sq ft	Land Protection Certified
CO_2 emissions	18 lbs, 12 lbs	18 lbs, 12 lbs	Certified CN2 Carbon Neutral
Water use	500 gal, 380 gal	500 gal, 380 gal	WaterSense Meets EPA Criteria
Feedlot use/grassfed label	Feedlot, Grassfed	None, American Grassfed	American Grassfed
Mortality rate/animal welfare label	5%, 2%	5%, 2%	Animal Welfare Approved
Added hormone use	Yes, No	None, No Added Hormones	No Added Hormones

	Option 1	Option 2	Option 3
Land Use:	320 sq ft	320 sq ft	
CO2 Emissions:	18 lbs	12 lbs	
Water Use:	500 gal	380 gal	
Finishing System:	Grass Fed	Feedlot	Would not purchase either
Mortality Rate:	5%	2%	
Added Hormone Use:	No	Yes	
Price:	$2.49/lb	$3.99/lb	

Figure 1. Text Design Example

	Option 1	Option 2	Option 3
Land Use:	320 sq ft	320 sq ft	Would not purchase either
CO2 Emissions:	18 lbs	12 lbs	
Water Use:	500 gal	380 gal	
Grassfed Label:	American Grassfed	None	
Mortality Rate:	5%	2%	
Added Hormone Use Label:	NO ADDED HORMONES	None	
Price:	$2.49/lb	$3.99/lb	

Figure 2. Visual Design Example

Figure 3. Label Design Example

Table 2. Observations by Design and Information Treatment

	Information Treatment			
Survey Design	**Control**	**Pro-Environment**	**Pro-Animal Welfare**	**Total**
Text	192	181	186	559
Visual	166	166	168	500
Labels	166	166	168	500
Total	524	513	522	1,559

Presentation Treatments

Respondents were randomly assigned to one of three presentation treatments: text, visual, or labels (see Figures 1–3 for examples). The text design was intended to be purely informational, requiring the participant to analyze each option closely to understand the trade-off being presented. The visual design used color, sizing, and the presence/absence of two labels to convey the attribute levels more intuitively and quickly than the text design. To illustrate the intended trade-off in a way that more closely resembles a grocery store setting, the final label design displayed options as packaged ground beef with various labels representing the attributes displayed in the other designs. Because no suitable label representation for mortality rate exists, it was replaced with an "Animal Welfare Approved" label. An important distinction between the use of labels in the visual and label designs is that the visual design specifies both presence and absence of the given label, where the label design doesn't indicate which labels are absent. So the more desirable attribute level in the label design (i.e., presence of a given label) could be seen as a "bonus" rather than as the opposite of an undesirable attribute level. Later we show that this has a significant effect on WTP estimates.

Information Treatments

In addition to presentation treatments, participants were randomly placed in one of three information treatments to determine whether the presentation of additional information prior to the CE could affect choice. The first information treatment is the control, in which no information was given prior to the choice option section of the survey. The respondents in the second information treatment (the "pro-environment" treatment) were shown a three-sentence summary of Capper's (2010) findings that demonstrates the environmental inefficiencies of grassfed systems compared to conventional beef production, including the use of feedlots and AGH. Members of the third information treatment (the "pro-animal welfare" treatment) were asked to read a brief overview of a study by Loerch and Fluharty (1999) that outlines the negative welfare effects that stressors from feedlots can produce on beef cattle. Table 2 reports total observations by design and information treatment.

Sample

We designed the surveys using Qualtrics and contracted with Dynata to deliver the survey to a sample of U.S. consumers during June and July 2019. Table 3 reports that the demographics of the collected sample are slightly older and more well-educated than a nationally representative sample (U.S. Census Bureau, 2017). The collected sample also has a higher proportion of female respondents (64%) than the national sample (51%). Because of our focus on grocery shoppers, the survey immediately ended for anyone who indicated they do 0% of the grocery shopping for their household (4.8% of total participants). While social norms are changing in the United States, a recent study sponsored by the Bureau of Labor Statistics found that in 71% families with children, grocery shopping is primarily done by the mother (Schaeffer, 2019). We also observed the demographics for each of the nine design/treatment groups to ensure that no treatment varied wildly from the collective sample. Table S4 in the online supplement (see www.jareonline.org) reports these results.

Table 3. Demographics of Sample Compared to U.S. Population

Demographic Characteristics	Description	U.S. Population (%)	Sample (%)
Gender	Male	49.2%	36.4%
	Female	50.8%	63.6%
Age	18–34	29.5%	28.4%
	34–54	32.8%	24.4%
	Over 54	37.7%	47.2%
Income	Low income, < $40,000	33.4%	32.6%
	Middle income, $40,000–$140,000	52.8%	54.7%
	High income, > $140,000	13.8%	12.7%
Education	Less than a bachelor's degree	71.6%	53.5%
	Bachelor's degree or higher	28.4%	46.5%

Choice Model

CE data were analyzed using a random utility model (McFadden, 1974), in which the utility each individual i receives from selecting choice option j in treatment t is

$$U_{itj} = V_{tj} + \varepsilon_{itj}, \tag{1}$$

where V_{tj} is the systematic portion of utility and ε_{itj} is the stochastic portion of utility, assumed to be known to the individual but unobservable to the analyst. Individual i is assumed to select choice option j over k if $U_{itj} > U_{itk}$. More generally, they will choose option j out of a set of J options if $U_{itj} > U_{itk}\ \forall\ k \in J$. If ε_{itj} is *i.i.d.* across alternatives and individuals and follows a Type 1 extreme value distribution, then $\text{Prob}(U_{itj} > U_{itk})$ is equal to

$$s_{tj} = \frac{\exp(V_{tj})}{\sum_{k=1}^{J} \exp(V_{tk})}, \tag{2}$$

where s_{tj} is the probability of selecting choice option j in treatment t. This is the multinomial logit (MNL) or conditional logit model. The term V_{tj} from equation (1) can be expanded to

$$V_{tj} = \beta_{tj} + \alpha_t p_j + \sum_{k=1}^{J} \theta_t^k d_j^k, \tag{3}$$

where β_{tj} is an alternative-specific constant (ASC) indicating the utility of option j in treatment t relative to the "purchase neither" option (the utility of which is normalized to 0), α_t is the marginal utility of change in price, p_j is the price of option j, d_j^k represent dummy variables indicating whether option j has the hypothesized more favorable attribute level (i.e., grassfed, AGH free, lower environmental inputs, and mortality rate) or the presence/absence of attribute label representations, and θ_t^k are consumer preferences for the more favorable level relative to the least favorable level for each kth attribute in treatment t. If two options for a pound of ground beef are identical in every way (including price), except one has a more favorable level of a given attribute ($d_{j=1}^k = 1$) while the other option does not ($d_{j=1}^k = 0$), then WTP for this given attribute can be calculated as $-\theta_t^k/\alpha_t$.

The MNL model assumes that all individuals have the same preferences. To relax this assumption and parsimoniously study the treatment effects, we also utilize the latent class model (LCM). The LCM assigns respondents, with some probability, into distinct groups or classes, each with distinct preferences (Greene and Hensher, 2013). The unconditional choice probability for the LCM is defined as

$$\text{Prob}(i \text{ chooses } j \text{ in treatment } t) = \sum_{c=1}^{C} P_{itc} \frac{\exp(V_{tjc})}{\sum_{k=1}^{K} \exp(V_{tkc})}, \tag{4}$$

Table 4. Likelihood Ratio Test (LRT) Results

Panel A. LRT 1: Text Design[a]

	Control	Pro-Environment	Pro-Animal Welfare	Pooled	Likelihood Ratio Test	
No. of participants	192	181	186	559	χ^2 statistic	78.06
No. of obs.	6,912	6,516	6,696	20,124	Critical value	28.87
Log-likelihood value	−2,177.26	−2,074.35	−2,251.23	−6,541.88	*p*-value	0.00

Panel B. LRT 2: Visual Design[b]

	Control	Pro-Environment	Pro-Animal Welfare	Pooled	Likelihood Ratio Test	
No. of participants	166	166	168	500	χ^2 statistic	38.15
No. of obs.	5,976	5,976	6,048	18,000	Critical value	28.87
Log-likelihood value	−1,881.88	−1,858.64	−1,916.93	−5,676.52	*p*-value	0.00

Panel C. LRT 3: Label Design[c]

	Control	Pro-Environment	Pro-Animal Welfare	Pooled	Likelihood Ratio Test	
No. of participants	166	166	168	500	χ^2 statistic	23.99
No. of obs.	5,976	5,976	6,048	18,000	Critical value	28.87
Log-likelihood value	−1,641.67	−1,650.92	−1,586.30	−4,890.88	*p*-value	0.16

Panel D. LRT 4: Control Treatment[d]

	Text Design	Visual Design	Label Design	Pooled	Likelihood Ratio Test	
No. of participants	192	166	166	524	χ^2 statistic	130.50
No. of obs.	6,912	5,976	5,976	18,864	Critical value	28.87
Log-likelihood value	−2,177.26	−1,881.88	−1,641.67	−5,766.06	*p*-value	0.00

Panel E. LRT 5: Pro-Environment Treatment[e]

	Text Design	Visual Design	Label Design	Pooled	Likelihood Ratio Test	
No. of participants	181	166	166	513	χ^2 statistic	176.40
No. of obs.	6,516	5,976	5,976	18,468	Critical value	28.87
Log-likelihood value	−2,074.35	−1,858.64	−1,650.92	−5,672.11	*p*-value	0.00

Panel F. LRT 6: Pro-Animal Welfare Treatment[f]

	Text Design	Visual Design	Label Design	Pooled	Likelihood Ratio Test	
No. of participants	186	168	168	522	χ^2 statistic	298.44
No. of obs.	6,696	6,048	6,048	1,8792	Critical value	28.87
Log-likelihood value	−2,251.23	−1,916.93	−1,586.3	−5,903.68	*p*-value	0.00

Notes: [a] Null hypothesis: Parameters for the text design are the same across information treatments.
[b] Null hypothesis: Parameters for the visual design are the same across information treatments.
[c] Null hypothesis: Parameters for the label design are the same across information treatments.
[d] Null hypothesis: Parameters for the control treatment are the same across designs.
[e] Null hypothesis: Parameters for the pro-environment treatment are the same across designs.
[f] Null hypothesis: Parameters for the pro-animal welfare treatment are the same across designs.

where P_{itc} is the probability that individual i is in treatment t and class c, and V_{tjc} is defined as in equation (3), except parameters are now specific to a given class c. We also specify $P_i tc$ to vary with treatment variables indicating the types of labels and the type of information provided; in practice, $P_i tc$ also has the MNL form. The Akaike information criterion (AIC) and Bayesian information criterion (BIC) model selection criteria are used to determined the number of classes. WTP for each class can be calculated as $-\theta_{tc}^{k}/\alpha_c$. Using the Krinsky–Robb bootstrap method, we establish confidence intervals for the WTP values.

Results

We begin by describing the results from the MNL models, which require fewer assumptions about model specification. We use the MNL estimates to determine whether data can be pooled across treatment groups before showing results from these models. We then move on to presenting results from the LCM.

Likelihood Ratio Test Results

Likelihood-ratio tests (LRTs) are used to determine whether preferences change by treatment. We first separate the data by survey design and run the MNL for each condition. Within each design, we separate the data further into each of the three information treatments, for an additional nine models. By comparing these unrestricted models to models that pool data by label design and/or information, the null hypothesis of equality of preference parameters across labels and information can be tested.[1] Table 4 reports the LRTs and resulting *p*-values. Results indicate the null hypothesis of preference equality is rejected for virtually every comparison, indicating that choices were significantly impacted by labels and information. The only exception is when comparing information treatments across the label design in which the null of equal preferences across information treatments cannot be rejected. One interpretation of this result is that the visual appeal of the labels overwhelms the impact of information; another interpretation is that the labels and information are perfect substitutes.

MNL Estimates

Table 5 shows the coefficient estimate results for the MNL models by design (but pooled across information treatment). While the alternative-specific constants (ASCs), Meat Options 1 and 2, are not among the original seven attributes we identify in the methodology, they do reveal the extent to which participants preferred selecting either meat option over the option to purchase neither. Beginning with the text design, all three environmental attributes have small and insignificant estimates, implying little consumer concern for those characteristics. Mortality rate is similarly insignificant, while grassfed and AGH free are significant. Both alternative specific constants are significant and positive, indicating people are likely to choose one of the meat options instead of the "none" option. For the visual design, all attribute estimates are positive and significant. In the label design, utility increases with the presence of all labels (other than the water use label, which is statistically insignificant). Price is negative and significant for all three designs, as expected.

We use the estimates from Table 5 to calculate mean WTP, shown in Figure 4. Participants in the text design have high WTP for grassfed and AGH free but are not influenced by mortality rate or any environmental attribute. The visual design produces positive WTP for all six attributes, although WTP for grassfed and AGH free are over twice those for the remaining attributes. Recall that the

[1] Tables S1–S3 in the online supplement report the MNL parameter estimates of the 9 unrestricted models (3 label conditions $\times$ 3 information treatments).

Table 5. Coefficient Estimates for Multinomial Logit Model by Survey Design

Attribute	Text Design	Visual Design	Label Design	Pooled
Land use	0.013	0.114***	0.254***	0.123***
	(0.035)	(0.036)	(0.039)	(0.021)
CO_2 emissions	0.012	0.201***	0.129***	0.117***
	(0.035)	(0.035)	(0.037)	(0.020)
Water Use	−0.021	0.086**	−0.038	0.006
	(0.037)	(0.038)	(0.039)	(0.022)
Finishing system/grassfed label	0.475***	0.494***	0.231***	0.407***
	(0.040)	(0.041)	(0.042)	(0.024)
Mortality rate/animal welfare label	0.038	0.124***	0.108***	0.092***
	(0.037)	(0.039)	(0.041)	(0.022)
Added hormone use	0.699***	0.550***	0.605***	0.623***
	(0.045)	(0.047)	(0.048)	(0.027)
Meat option 1	0.629***	0.795***	1.982***	1.054***
	(0.124)	(0.135)	(0.142)	(0.076)
Meat option 2	0.702***	0.862***	2.057***	1.125***
	(0.122)	(0.134)	(0.142)	(0.075)
Price	−0.298***	−0.290***	−0.476***	−0.345***
	(0.018)	(0.019)	(0.020)	(0.011)
Log-likelihood function	−6,541.88	−5,676.52	−4,890.88	−17,360.65
Akaike information criterion	13,101.8	11,371.0	9,799.8	34,739.3

Notes: Double and triple asterisks (**, ***) indicate significance at 5% and 1% levels, respectively. Values in parentheses are standard errors.

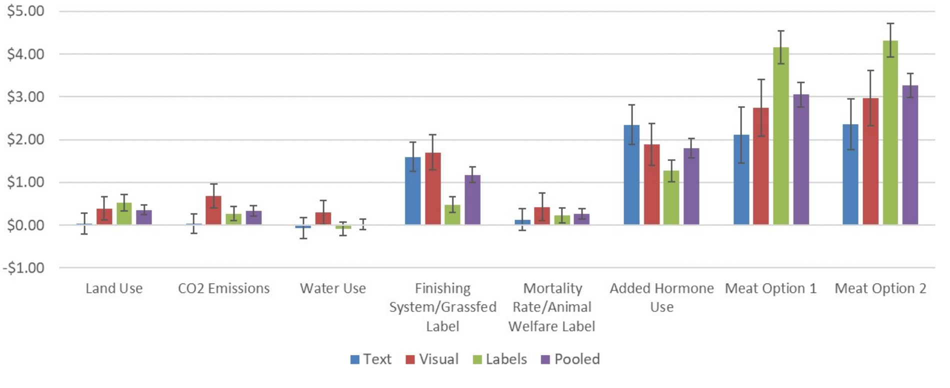

Figure 4. Mean Marginal Willingness to Pay for Multinomial Logit by Survey Design

visual design used coloring and sizing to display levels of environmental input, so the relatively higher WTP for environmental attributes in the visual design is not surprising.

The label design produces much less variability across attribute WTP. Interestingly, the preference for grassfed beef in the label design is less than a third of that in the other survey designs. Participants actually had slightly greater WTP for the land protection certified label than for the grassfed label.

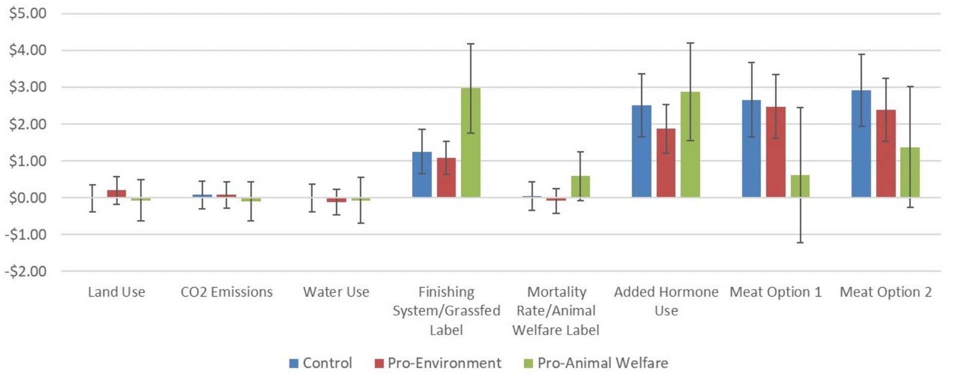

Figure 5. Mean Marginal Willingness to Pay by Information Treatment for Text Design

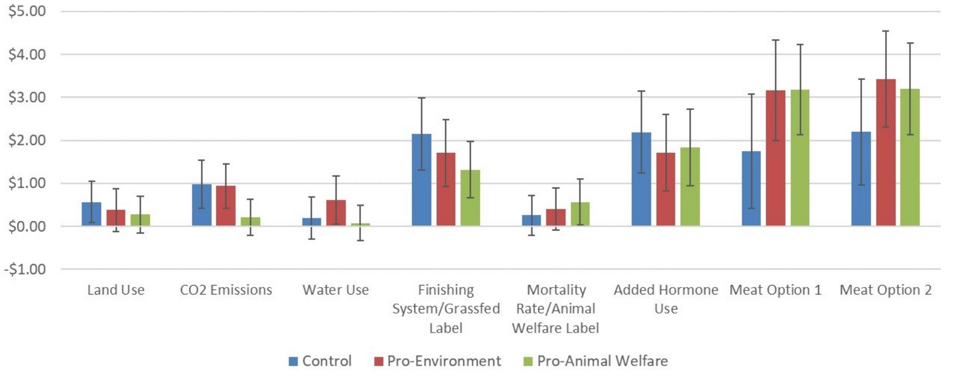

Figure 6. Mean Marginal Willingness to Pay by Information Treatment for Visual Design

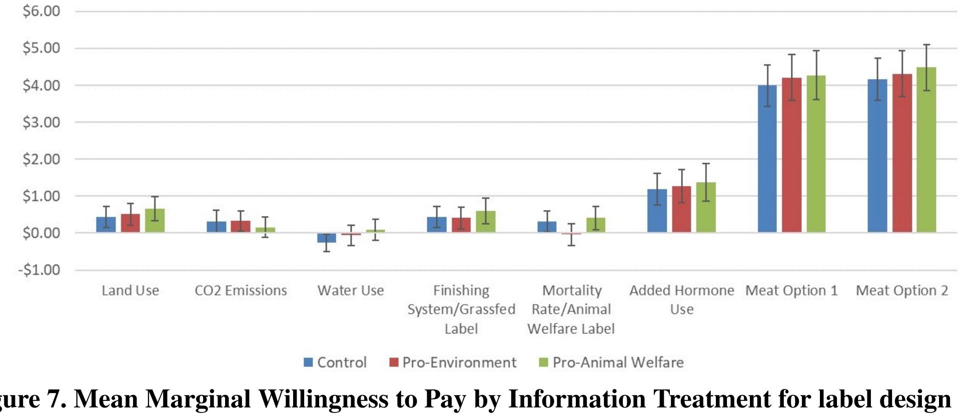

Figure 7. Mean Marginal Willingness to Pay by Information Treatment for label design

For both ASCs, mean WTP in the label design is 1.5 times higher than in the visual design and nearly 2 times higher than in the text design. This suggests that consumers' likelihood of selecting a meat option increases as the CE becomes more akin to a grocery store setting (i.e., use of labels and images of beef). High WTP for meat options in the label design could also be due to the lack of stated negative effects of a selection in the label design. The presence of a given label could be seen as a bonus to an already attractive product rather than as a mix of desirable and undesirable attribute levels. This suggests that consumers in the text and visual designs might exhibit lower WTP in an actual purchasing scenario.

Table 6. Coefficient Estimates for Latent Class Model

Attributes	Class 1	Class 2	Class 3	Class 4	Class 5
Land use	0.20**	0.14***	0.24	−0.05	0.51
	(0.09)	(0.05)	(0.41)	(0.05)	(0.34)
CO_2 emissions	−0.31***	0.14***	0.28	0.09	0.61
	(0.11)	(0.04)	(0.35)	(0.05)	(0.42)
Water use	0.14	0.14***	−0.16	0.18***	0.54
	(0.12)	(0.05)	(0.43)	(0.06)	(0.50)
Finishing system/grassfed label	0.30***	0.60***	−0.06	0.35***	1.00
	(0.09)	(0.05)	(0.47)	(0.05)	(0.58)
Mortality rate/animal welfare label	0.09	0.17***	0.89**	0.05	0.56
	(0.09)	(0.05)	(0.35)	(0.05)	(0.38)
Added hormone use	1.85**	0.16***	1.23***	0.52***	1.18***
	(0.12)	(0.08)	(0.42)	(0.05)	(0.39)
Meat option 1	4.96***	2.92***	7.40***	−0.56***	−6.69***
	(0.26)	(0.31)	(1.58)	(0.17)	(1.15)
Meat option 2	5.51***	2.94***	7.76***	−0.37**	−6.64***
	(0.26)	(0.31)	(1.68)	(0.16)	(1.01)
Price	−1.23***	−0.05	−3.51***	−0.06**	0.08
	(0.04)	(0.04)	(0.41)	(0.02)	(0.14)
Class probability	39.8%	26.5%	4.6%	20.1%	9.0%

Class Identifiers	Levels	Class 1	Class 2	Class 3	Class 4	Class 5
Constant	n/a	1.81**	0.73	−1.48	−1.10	0
		(0.45)	(0.49)	(0.92)	(0.60)	0
Gender	1 = Male	0.40	0.67**	0.66	0.30	0
		(0.22)	(0.24)	(0.37)	(0.26)	0
Age	18–34	0.01	1.32**	−0.68	1.27**	0
		(0.28)	(0.28)	(0.55)	(0.29)	0
	35–54	0.18	0.84**	−0.12	0.30	0
		(0.26)	(0.27)	(0.43)	(0.29)	0
Education	1 = Bachelor's	−0.29	−0.47*	−0.28	−0.42	0
	degree or higher	(0.22)	(0.24)	(0.36)	(0.25)	0
Income	Low income,	0.20	0.18	1.00	0.37	0
	$40,000	(0.34)	(0.37)	(0.60)	(0.40)	0
	Middle income,	0.40	0.34	0.81	0.48	0
	$40,000–$140,000	(0.29)	(0.32)	(0.58)	(0.35)	0
Design/	Text/Control	−0.31	−0.28	0.77	1.97***	0
Treatment		(0.50)	(0.54)	(0.82)	(0.62)	0
	Text/Pro-environment	−1.14***	−1.48***	−0.17	0.79	0
		(0.43)	(0.47)	(0.80)	(0.57)	0

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Table 6. – continued from previous page

Class Identifiers	Levels	Class 1	Class 2	Class 3	Class 4	Class 5
Design/	Text/Pro-animal	−1.51***	−0.97**	−0.08	1.46***	0
Treatment	welfare	(0.44)	(0.47)	(0.82)	(0.56)	0
	Visual/Control	−1.00**	−0.37	−0.44	1.10	0
		(0.45)	(0.47)	(0.87)	(0.58)	0
	Visual/Pro-	−0.39	0.16	−0.06	1.81***	0
	environment	(0.49)	(0.52)	(0.95)	(0.62)	0
	Visual/Pro-animal	−0.74	−0.44	0.04	1.55***	0
	welfare	(0.46)	(0.49)	(0.85)	(0.59)	0
	Labels/Control	−0.23	−0.32	0.12	−0.07	0
		(0.46)	(0.50)	(0.82)	(0.68)	0
	Labels/Pro	−0.12	−0.36	0.46	0.23	0
	environment	(0.47)	(0.51)	(0.82)	(0.67)	0
Log-likelihood function		−12,805.06				
Akaike information criterion		25,820.1				

Notes: Double and triple asterisks (**, ***) indicate significance at the 5% and 1% levels, respectively. Values in parentheses are standard errors.

Using the treatment-specific MNL estimates (see Tables S1–S3 in the online supplement), we calculated WTP for each attribute for each survey design broken down by information treatment, as shown in Figures 5–7. Recall from the LRT results that we expect to see variation across treatments for the text and visual designs but not for the label design. In the text design, participants in the pro-animal welfare treatment have a mean WTP for grassfed beef over two times greater than the control and pro-environment treatments. The pro-animal welfare information also results in a significantly lower WTP for the ASCs. Participants in the text design were only influenced by the grassfed and AGH-free attributes. Figure 6 shows WTP variation across information treatments, but this variation does not appear to be caused by the information content. The consistency of WTP across treatments in the label design implies that additional information had no effect on consumer choice.

Latent Class Model Results

In addition to the MNL, we use the complete dataset from all three surveys to estimate an LCM. The class membership identifiers, P_{it} is specified as a function of 14 variables, including sociodemographic characteristics and dummies indicating to which survey design and information treatment the respondent was assigned. To select the number of classes for the LCM, we observed the AIC across two-, three-, four-, five-, and six-class models. The AIC continued to decrease until the six-class LCM resulted in a model that would not converge. Thus, we utilized a five-class LCM.

Table 6 shows the attribute coefficients by class. Class 1 has positive and significant coefficients for land use, grassfed, and AGH-free attributes. All attributes for class 2 have positive coefficients, the largest of which is grassfed. Mortality rate and AGH free are the only positive, significant attributes for class 3. Class 4 has positive coefficients for water use, grassfed, and AGH free, while class 5 has positive significance for the grassfed and AGH-free attributes. Classes 1, 2, and 3 have positive coefficients for the ASCs, while classes 4 and 5 have negative coefficients.

Table 6 also reports class membership identifiers. Note that all coefficients are relative to class 5. Classes 1, 2, and 3 are more likely to be male. Classes 2 and 4 are most likely to be younger and least likely to have a bachelor's degree or higher. Classes 1 and 2 have similar likelihoods of being in each design/treatment, both of which are least likely to have been shown the text design. Class

4 has a high likelihood of having been shown the text or visual designs, while classes 3 and 5 are distributed more or less evenly among the designs/treatments.

Interpretation of WTP in the LCM, shown in Table 7, is somewhat precarious given the insignificant price coefficients for classes 2 and 5. However, we can compare the relationships of the other coefficients in each class to understand more about preference sets. The first class has the highest membership probability (42.2%), and their WTP is slightly lower than the overall results from the MNL model (except for grassfed, which is significantly lower). Recall from the MNL results that WTP for AGH-free beef was only 1.5 times higher than that for grassfed. For class 1, that multiplier is 6.25.

This disparity is explained in part by class 2 (26.5% membership probability), which has an insignificant price coefficient resulting in extreme confidence intervals and unreliable WTP measures. However, by going back to Table 6, we see this class has a coefficient nearly 4 times greater for grassfed than for the remaining five attributes. The positive coefficients for the ASCs also suggest that class 2 prefers to purchase meat rather than not. So it seems classes 1 and 2 could be labeled "normal beef eaters" but with distinct preferences for AGH-free beef and grassfed beef, respectively.

Class 3 has the lowest membership probability (4.6%); they have low WTP for mortality/animal welfare and AGH-free beef but paid little attention to the remaining attributes. This class does have a positive WTP for the ASCs, implying that this class was extremely price sensitive and selected whichever meat option had the lowest price, with slight concern for low mortality and AGH-free attributes. Thus, class 3 can be called the "price sensitive with preference for animal welfare" class.

Class 4 (20.1% membership probability) has negative WTP for both ASCs but relatively large WTP for the remaining attributes, save land use. We can infer that this class was not as keen to select meat options as the first three classes but had relatively greater WTP for attributes when a meat option was selected. Class 4 is the "selective consumer" class since they were reluctant to select beef options without desirable attribute levels.

Class 5 (9.0% membership probability) has a positive price coefficient. For this reason, WTP for this class is omitted from Table 7. However, we can see from Table 6 that the relationships between the six nonprice attribute coefficients and the two ASCs are proportional to the other classes. The coefficients for both meat options are large and negative, implying that this class likely selected the "purchase neither" option most frequently. We therefore refer to class 5 as the "meat-averse" class.

Simulated Choice Scenarios

To help determine the trade-off consumers are willing (or unwilling) to make between environmental and animal welfare characteristics, we use the LCM to run choice option simulations. Consider a choice set consisting of three ground beef options. Option 1 has the more desirable level for each of the three environmental attributes and the less desirable level for each of the three animal welfare attributes. Option 2 has the opposite levels for each attribute (high environmental impact with better animal welfare), at the same price as option 1 (both assumed $3.99/lb). Option 3 is to purchase neither of the first two options. We use demographic means and dummy variables for each design/treatment and the LCM estimates to generate choice selection probability for each of the nine design/information treatments. We then calculate a weighted average choice probability across the information treatments for each survey design. These choice probabilities are given in Figure 8.

Consistent with our previous results, respondents assigned to the text design have the highest probability of selecting neither meat option while those assigned to the label design have the lowest probability. Those assigned to the visual design have the highest likelihood of selecting the option with more desirable levels of environmental impact. This simulation reveals that participants were 3–4 times more likely to select the option with better animal welfare than reduced environmental cost at the median price level.

Table 7. Mean Marginal WTP for Latent Class Model

	Class 1 (39.8%)		Class 2 (26.5%)		Class 3 (4.6%)		Class 4 (20.1%)	
Attribute	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
Land use	$0.16	[$0.02, $0.30]	$3.09	[−$89.33, $95.51]	$0.07	[−$0.15, $0.29]	−$0.83	[−$24.89, $23.22]
CO_2 emissions	−$0.25	[−$0.4, −$0.10]	$2.92	[−$91.19, $97.02]	$0.08	[−$0.14, $0.3]	$1.64	[−$44.44, $47.72]
Water use	$0.12	[−$0.07, $0.30]	$2.93	[−$70.22, $76.08]	−$0.04	[−$0.3, $0.21]	$3.17	[−$117.3, $123.64]
Finishing system/grassfed label	$0.24	[$0.10, $0.39]	$12.80	[−$274.82, $300.42]	−$0.02	[−$0.31, $0.28]	$6.41	[−$181.12, $193.94]
Mortality rate/animal welfare label	$0.08	[−$0.04, $0.19]	$3.59	[−$86.90, $94.07]	$0.25	[$0.03, $0.48]	$0.88	[−$37.65, $39.42]
Added hormone use	$1.50	[$1.33, $1.67]	$3.46	[−$126.89, $133.81]	$0.35	[$0.09, $0.61]	$9.33	[−$269.4, $288.07]
Meat option 1	$4.02	[$3.67, $4.36]	$62.53	[−$1024.52, $1149.57]	$2.11	[$1.55, $2.66]	−$10.13	[−$465.43, $445.17]
Meat option 2	$4.46	[$4.17, $4.76]	$62.89	[−$1035.63, $1161.4]	$2.21	[$1.61, $2.81]	−$6.66	[−$354.65, $341.34]

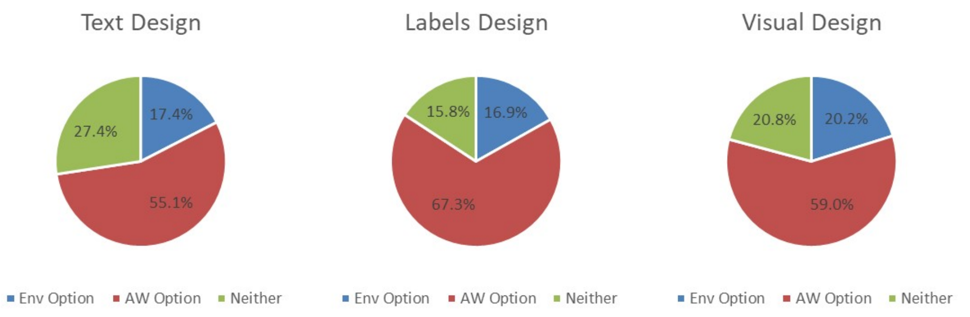

Figure 8. Choice Selection Likelihoods: Simulation 1

We run another test using the same attribute levels as in the previous simulation. Knowing that consumers were more likely to select the animal welfare option, we give the environmental option the lowest price level ($1.99/lb). We then simulate the price for the animal welfare option at which consumers would become indifferent between the two meat options. At a price of $4.04/lb for the animal welfare option, the selection likelihoods for the two meat options both equal 41.2%, with the remaining 17.6% selecting the "purchase neither" option. Consumers are therefore willing to spend over 2 times as much for an option high in animal welfare than one that demonstrates lower environmental cost.

Discussion

Across all presentation designs and information treatments, participants are far more willing to pay for animal welfare attributes than for environmental efficiencies. The three attributes representing animal welfare (particularly grassfed and AGH free) elicited higher overall WTP than the three attributes representing environmental sustainability. Results indicate that unique presentations of a single CE can have a significant impact on consumer responses. Participants shown the purely informational presentation (text design) disregarded all numerically presented attributes (land use, water use, CO_2 emissions, mortality rate). Instead, they chose options solely on price and whether the beef was grassfed with no AGH. The visual presentation incorporated color and size to illustrate the numeric attributes more intuitively. This group had significantly higher WTP for environmental attributes than those in the other presentations, although still lower than their WTP for animal welfare attributes. The label presentation was designed to more realistically mimic a grocery store setting, using images of packages of ground beef with labels representing each attribute besides price. Participants shown the label design had the lowest variance across attributes for WTP and relatively lower attribute WTP overall. Somewhat surprisingly, the land protection certified label produced slightly higher WTP than the grassfed label.

The use of pro-animal welfare information in the text design produced a significant increase in WTP for animal welfare attributes as well as lower preference for ASCs. Pro-environment information had no effect on any design.

In the label design, participants' WTP for a meat option over a "purchase neither" option was 1.5–2 times higher than that of participants the other designs. This group was also the most heavily influenced by price and had relatively low attribute WTP overall. One potential reason for this is that the label design does not display a "less desirable" level of each attribute, only the absence of a desirable label. It is possible these labels are seen as bonuses to an already desirable product rather than as a better alternative to an explicitly "undesirable" quality. Another possible explanation is that the use of images of ground beef causes participants to see each option as an actual product rather than as a hypothetical collection of attributes. The disparity in attribute WTP across the three presentation styles could imply that consumers are less willing to pay for a given attribute in a grocery store than they are in a CE.

A potential limitation of this study is the degree to which consumers relate the attributes presented in this study with the issues of environmental impact and animal welfare. It is possible that consumers equate grassfed beef with environmental sustainability (Stampa, Schipmann-Schwarze, and Hamm, 2020) or that high WTP for AGH-free beef is driven by safety concerns rather than considerations of animal welfare (Yang, Raper, and Lusk, 2017). There is reason to believe that animal welfare is the primary association with grassfed and AGH-free beef (Pirog, 2004; Kühl, Gauly, and Spiller, 2019; Ventura et al., 2016; Cardoso, von Keyserlingk, and Hötzel, 2019), but a clearer understanding of how consumers perceive the environmental and welfare consequences of beef production could enhance the findings of this study.

It is clear that consumers prefer to pay more for animal welfare attributes of beef (specifically grassfed and no AGH) than for environmentally conscious attributes. However, this preference can be swayed slightly by using different presentation styles and providing additional information.

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Online Supplement: Trade-Off between Animal Welfare and Environmental Impacts of Beef Production: An Analysis of Presentation Effects on Consumer Choice

Jacob S. Schmiess and Jayson L. Lusk

Table S1. Coefficient Estimates by Information Treatment for Text Design

Attribute	Text Design	Visual Design	Label Design	Pooled
Land use	−0.008	0.075	−0.015	0.013
	(0.060)	(0.063)	(0.060)	(0.035)
CO_2 emissions	0.025	0.032	−0.020	0.012
	(0.059)	(0.062)	(0.060)	(0.035)
Water use	−0.001	−0.044	−0.014	−0.021
	(0.063)	(0.066)	(0.064)	(0.037)
Finishing system/grassfed label	0.397***	0.405***	0.626***	0.475***
	(0.068)	(0.071)	(0.069)	(0.040)
Mortality rate/animal welfare aabel	0.013	−0.029	0.125***	0.038
	(0.064)	(0.067)	(0.064)	(0.037)
Added hormone use	0.795***	0.670***	0.608***	0.699***
	(0.077)	(0.079)	(0.077)	(0.045)
Meat option 1	0.844***	0.925***	0.128	0.629***
	(0.215)	(0.217)	(0.216)	(0.124)
Meat option 2	0.927***	0.892***	0.291	0.702***
	(0.212)	(0.213)	(0.212)	(0.122)
Price	−0.317***	−0.373***	−0.211***	−0.298***
	(0.030)	(0.031)	(0.030)	(0.018)
No. of participants	192	181	186	559
No. of observations	6,912	6,516	6,696	20,124
Log-likelihood value	−2,177.26	−2,074.35	−2,251.23	−6,541.88
Akaike information criterion	4,372.5	4,166.7	4,520.5	13,101.8

Notes: Double and triple asterisks (**, ***) indicate significance at the 5% and 1% levels, respectively. Values in parentheses are standard errors.

Table S2. Coefficient Estimates by Information Treatment for Visual Design

Attribute	Text Design	Visual Design	Label Design	Pooled
Land use	0.160**	0.108	0.088	0.114***
	(0.065)	(0.063)	(0.063)	(0.036)
CO_2 emissions	0.277***	0.265***	0.068	0.201***
	(0.063)	(0.060)	(0.061)	(0.035)
Water use	0.052	0.176***	0.023	0.086**
	(0.066)	(0.065)	(0.065)	(0.038)
Finishing system/grassfed label	0.605***	0.480***	0.409***	0.494***
	(0.074)	(0.071)	(0.071)	(0.041)
Mortality rate/animal welfare label	0.074	0.117	0.178***	0.124***
	(0.069)	(0.067)	(0.067)	(0.039)
Added hormone use	0.618***	0.482***	0.565***	0.550***
	(0.083)	(0.081)	(0.080)	(0.047)
Meat option 1	0.494**	0.894***	0.982***	0.795***
	(0.237)	(0.237)	(0.230)	(0.135)
Meat option 2	0.620***	0.966***	0.991***	0.862***
	(0.234)	(0.237)	(0.229)	(0.134)
Price	−0.282***	−0.282***	0.309***	−0.290***
	(0.033)	(0.033)	(0.033)	(0.019)
No. of participants	166	166	168	500
No. of observations	5,976	5,976	6,048	18,000
Log-likelihood value	−1,881.88	−1,858.64	−1,916.93	−5,676.52
Akaike information criterion	3,781.8	3,735.3	3,851.9	11,371.0

Notes: Double and triple asterisks (**, ***) indicate significance at the 5% and 1% levels, respectively. Values in parentheses are standard errors.

Table S3. Coefficient Estimates by Information Treatment for Label Design

Attribute	Control	Pro-Environment	Pro-Animal Welfare	Pooled
Land use	0.217***	0.239***	0.308***	0.254***
	(0.068)	(0.067)	(0.067)	(0.039)
CO_2 emissions	0.159**	0.157**	0.074	0.129***
	(0.065)	(0.064)	(0.064)	(0.037)
Water use	−0.130	−0.027	0.044	−0.038
	(0.068)	(0.067)	(0.069)	(0.039)
Finishing system/grassfed label	0.217***	0.195***	0.281***	0.231***
	(0.074)	(0.073)	(0.074)	(0.042)
Mortality rate/animal welfare label	0.158**	−0.017	0.189***	0.108***
	(0.072)	(0.070)	(0.071)	(0.041)
Added hormone use	0.585***	0.602***	0.639***	0.605***
	(0.083)	(0.082)	(0.085)	(0.048)
Meat option 1	1.966***	1.989***	1.992***	1.982***
	(0.242)	(0.243)	(0.254)	(0.142)
Meat option 2	2.050***	2.035***	2.091***	2.058***
	(0.243)	(0.242)	(0.255)	(0.142)
Price	−0.492***	−0.473***	−0.466***	−0.476***
	(0.034)	(0.034)	(0.036)	(0.020)
No. of participants	166	166	168	500
No. of observations	5,976	5,976	6,048	18,000
Log-likelihood value	−1,641.67	−1,650.92	−1,586.30	−4,890.88
Akaike information criterion	3,301.3	3,319.8	3,190.6	9,799.8

Notes: Double and triple asterisks (**, ***) indicate significance at the 5% and 1% levels, respectively. Values in parentheses are standard errors.

Table S4. Sample Demographics by Design and Information Treatment

		% U.S.	% Sample	Text Control	Visual Control	Labels Control	Text Pro-Env	Visual Pro-Env	Labels Pro-Env	Text Pro-AW	Visual Pro-AW	Labels Pro-AW
Gender	Male	49%	36%	37%	34%	37%	36%	28%	42%	38%	42%	34%
	Female	51%	64%	63%	66%	63%	64%	72%	58%	62%	58%	66%
Age	18–34	30%	28%	30%	25%	23%	30%	30%	30%	27%	27%	34%
	34–54	33%	24%	22%	28%	23%	24%	24%	25%	27%	23%	24%
	Over 54	38%	47%	48%	47%	54%	46%	46%	45%	45%	51%	42%
Income	Low income, <$40,000	33%	33%	39%	33%	31%	35%	30%	26%	32%	33%	34%
	Middle income, $40,000–$140,000	53%	55%	50%	57%	54%	52%	58%	61%	58%	52%	51%
	High income, <$140,000	14%	13%	11%	11%	15%	13%	12%	13%	10%	15%	15%
Education	Less than bachelor's degree	72%	54%	57%	58%	50%	54%	58%	51%	54%	46%	54%
	Bachelor's degree or higher	28%	47%	43%	42%	50%	46%	42%	49%	46%	54%	46%